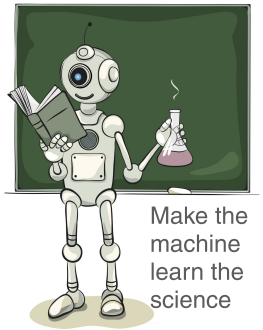
Graph Neural Network for Position Reconstruction

Shixiao Liang



DIDACTS

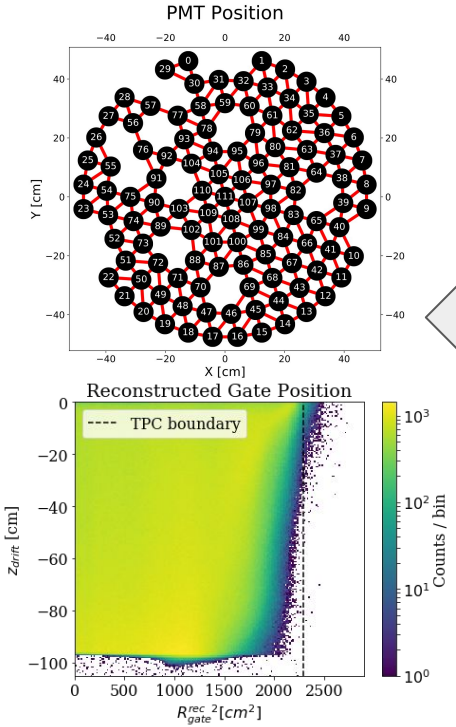
Data-Intensive Discovery Accelerated by Computational Techniques for Science

RICE

DIDACTS : a collaboration of physicists and ML experts

Challenges:
After Pulse Signals
Photoionization Signals
Dead PMTs
Saturated WFs
...

Consequences:
Surface events inside FV
Events outside the detector
...



Technics:

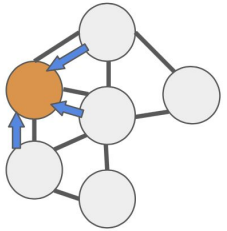
Graph Neural Networks

Probabilistic Graphical Models

Inverse Problem

...

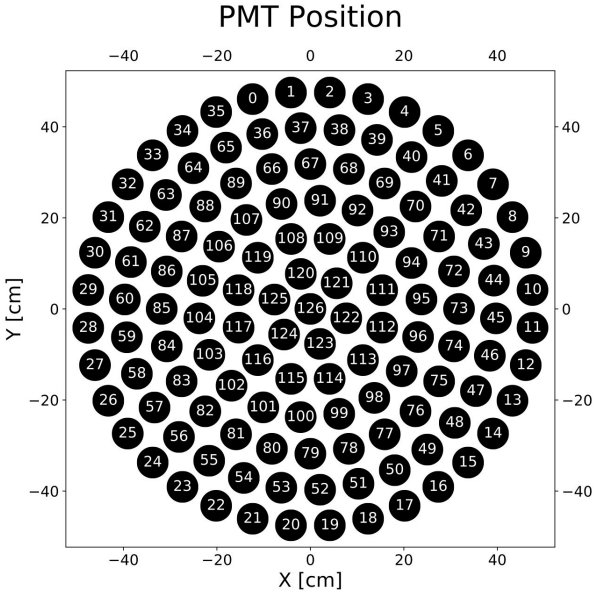
Graph Neural Networks



- Deep Learning on graph domain
- Information passes between nodes through edges

Advantages:

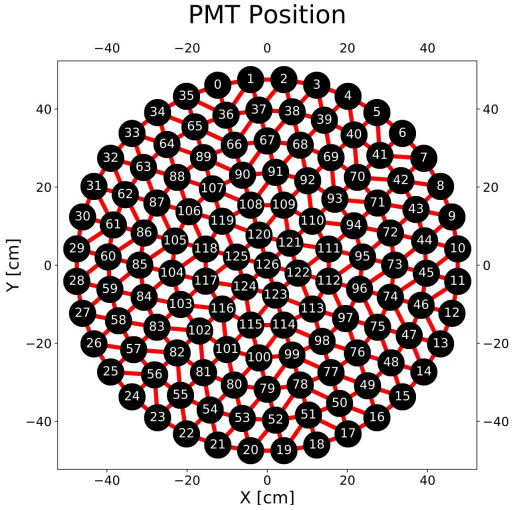
- Graph reflects arrangement of PMT array & TPC shape
- Shared weights: locality / prevent overfitting
- Resistant to noises

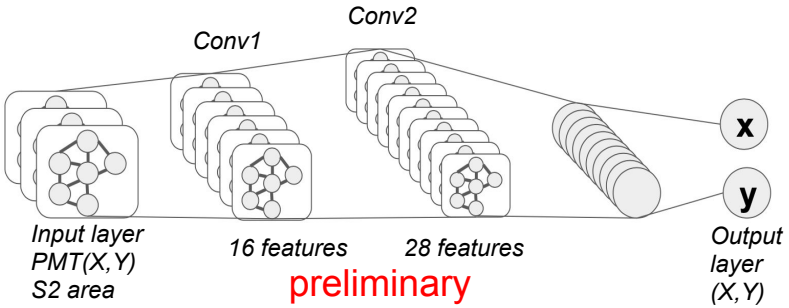


Current Status

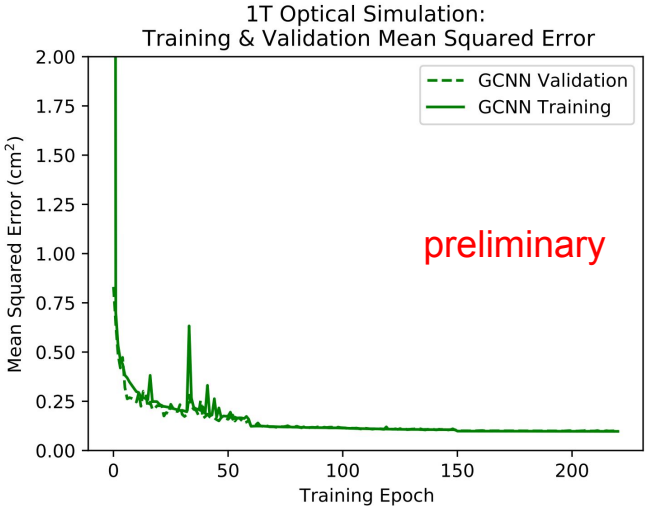
Model for ideal detector (no dead PMT)

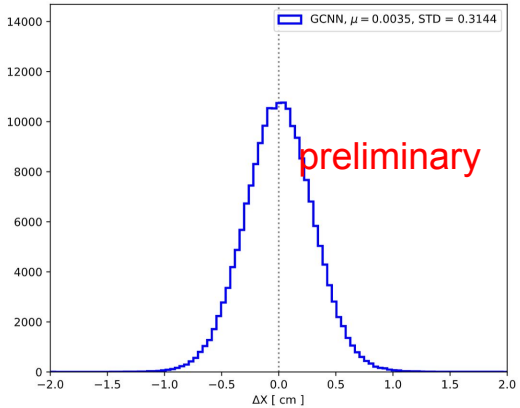
- Graph construction:
  PMT as nodes
  Delaunay triangulation
- Implementation:
  Pytorch + Pytorch Geometric
- Data set:
  GEANT-based optical simulation
- Input node features:
  - X position of PMT
  - Y position of PMT
  - Integrated S2 area

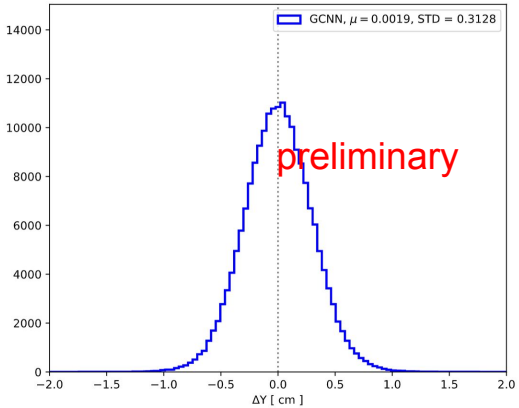




Current Status



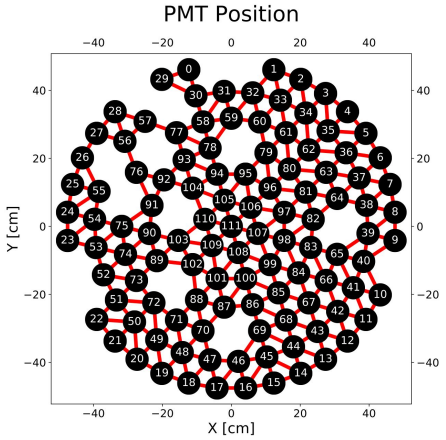




Next Steps & Summary

Go further with GNN:

- Optimize on graph structure
- Complete MC simulation: add detector effects (PMT gains, etc)
- Add time domain
- Find adequate pooling method
- Train the model on data
- Reconstruct position and energy at the same time



Summary:

- **DIDACTS**
- Graph Neural Networks have potential
- Developed GNN model for position reconstruction
- More GNN works in the future